Observation of $B \to \mu \nu D^{**} X$

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- D** are orbitally excited D meson states, see diagram
- In heavy quark limit expect two sets of doublet states
  - Two broad (decay through S-wave)
  - Two narrow (decay through D-wave)
- Narrow D**
  - $D^0_1(2420) \to D^{*+} \pi^-$
  - $D^{*0}_2(2460) \to D^{*+} \pi^-$
    - One of decay channels

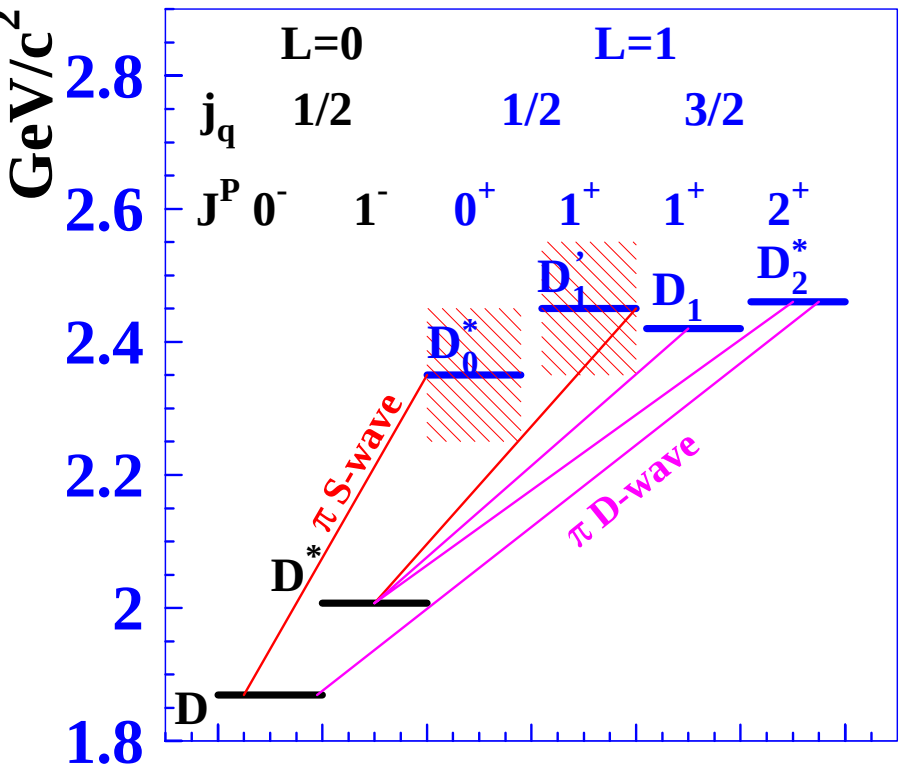
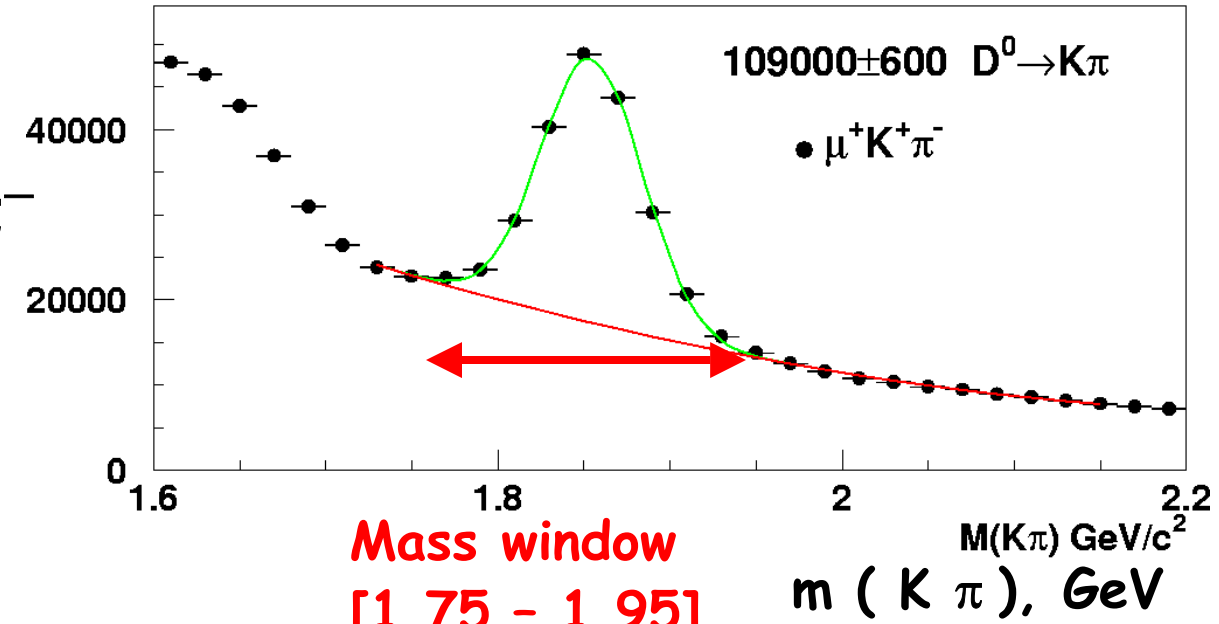


Figure from Belle, hep-ex/0307021

D^0 sample

- D_1^0, D_2^{*0} have been observed and studied in several experiments, most recently by BaBar and Belle in $B^- \rightarrow D^{**0}\ \pi^-$
- We study D_1^0, D_2^{*0} produced in semileptonic B decays
- Started with B -> μ D^0 X sample

$B \rightarrow \mu^+ D^0 X$, $D^0 \rightarrow K^+\pi^-$

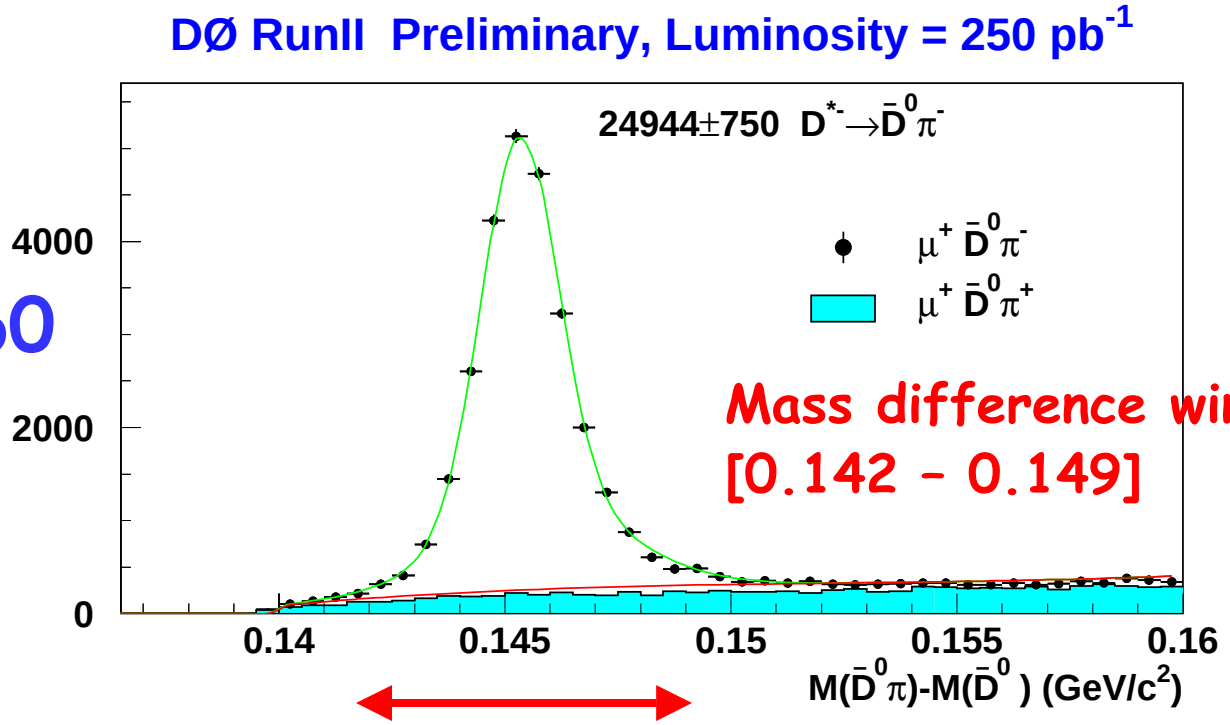


D* sample

- Selections
  - Additional pion pt>0.18 GeV
  - Right charge correlation with muon

28730 +/- 360

$D^{*-} \rightarrow \bar{D}^0 \pi^-$

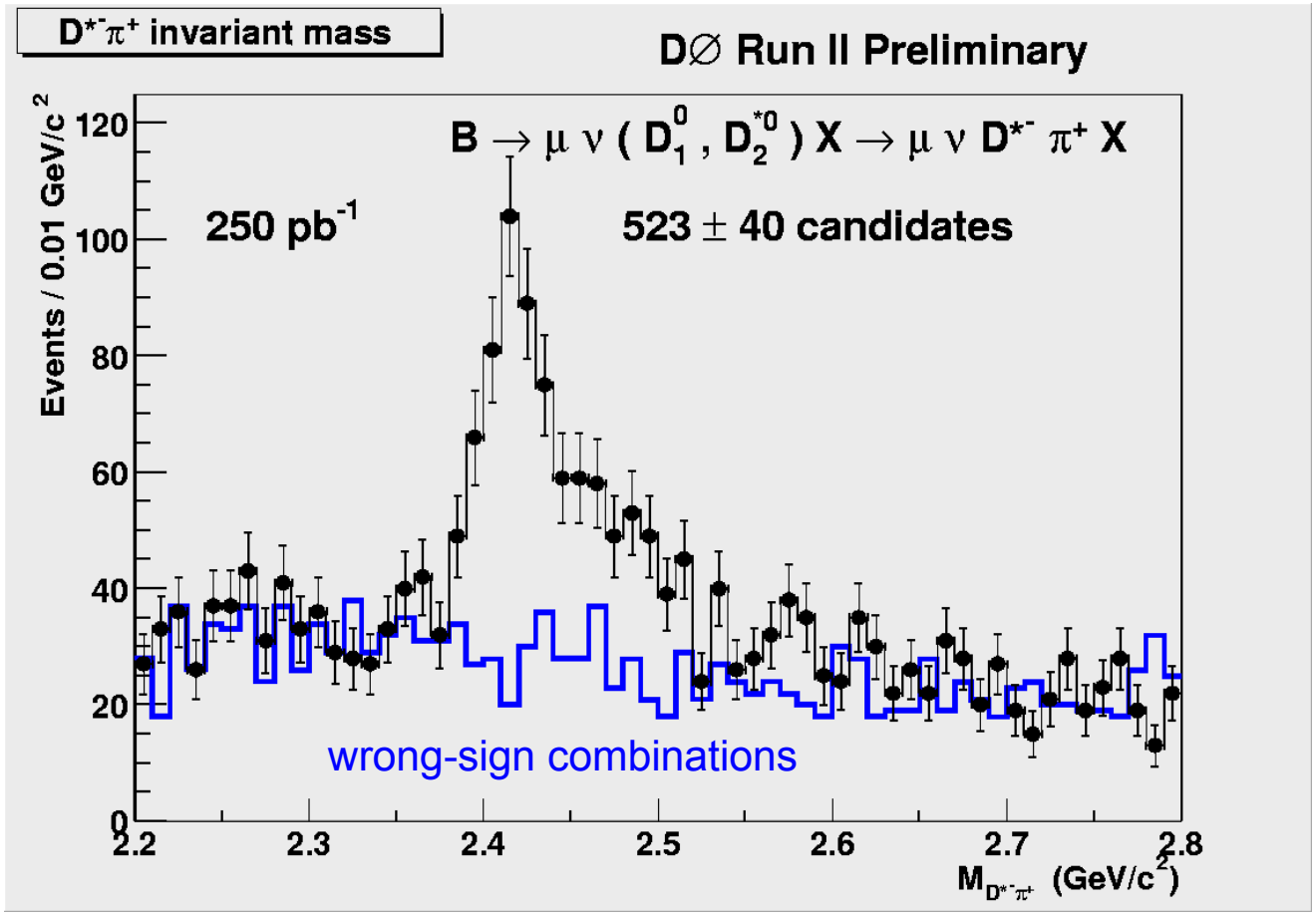


D** selections

- D** selections
  - Additional pion
    - pt > 0.3 GeV, # SMT hits > 1
    - Right charge correlation
    - IP significance wrt PV / IP significance wrt D** vtx > 4
- B selections
  - # CFT hits > 5 for all tracks
  - B vertex χ^2 < 25
    - Made of all D** tracks and muon
  - Lifetime cuts
    - Lxy significance > 3

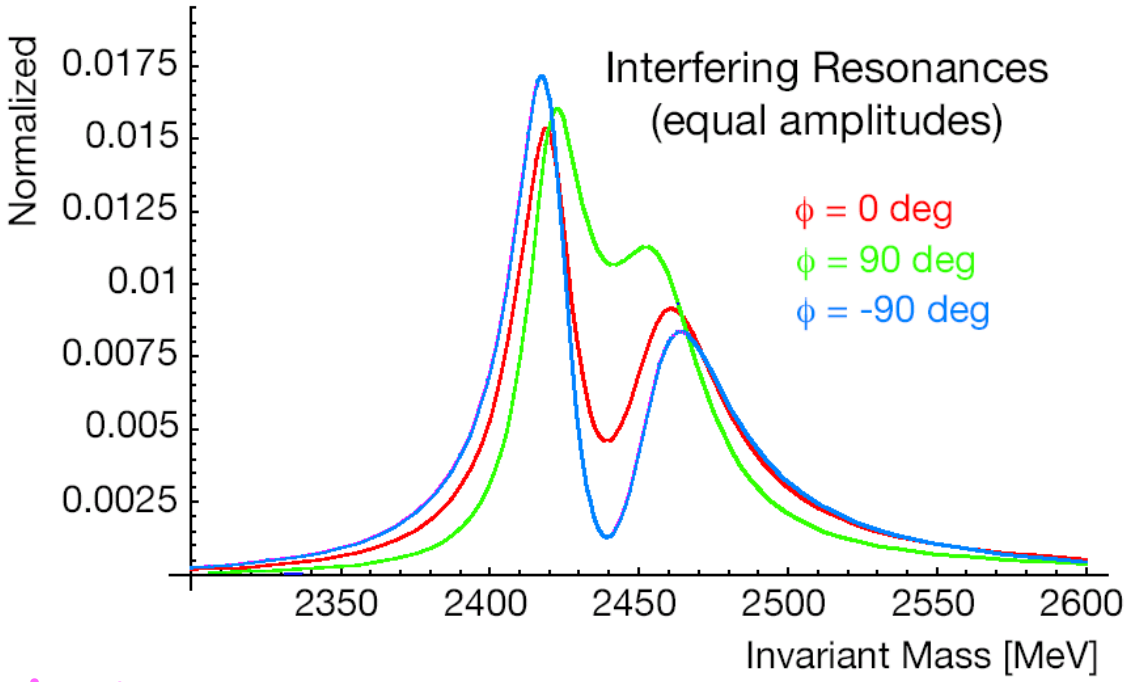
D** Signal

- Look at invariant mass of $D^{*-}\ \pi^+$ system
- Observed merged $D_1^0(2420)$ and $D_2^{*0}(2460)$



Interference effects

- Two interfering Breit-Wigner D** states with mass/width as measured by Belle (no resolution effects included)



- Work in progress: extract separate amplitude for each state and relative phase of interference

Measurement of Br

- Experimentally determine total # of events in two narrow peaks
  - $N(D_1)+N(D^*_2) = 523 \pm 40$
- Measure Br of B → μ ν narrow D** X
  - Normalize to known Br ($B \to D^{*+} \mu \nu X$)

$$Br(B \to \{D_1^0, D_2^{*0}\} \mu \nu X) \cdot Br(\{D_1^0, D_2^{*0}\} \to D^{*+} \pi^-) =$$

$$0.280 \pm 0.021 \text{ (stat)} \pm 0.088 \text{ (syst)} \%$$

- Can be compared to LEP measurement of total D** Br

$$Br(B \to D^{**+} \pi^- \mu \nu X) = (0.48 \pm 0.10)\%$$

  - ~ half of the rate goes through narrow states

Systematic errors

- Considered the following systematic effects

Source	Br absolute error
D^* branching rates	0.020%
MC statistics	0.023%
Normalization to D^*/D^0	0.023%
$P_t^{\pi}{}^{**}$ dependence	0.052%
Possible contribution from wide resonance	0.039%
Possible interference effects of D_1^0 and D_2^{*0}	0.040%
Different modelling of D^* fit	0.010%
Trigger bias	0.020%
Total systematic error	**0.088%**

- Can hope to decrease the main contributors in the future

What else can be measured?

- Theoretically semileptonic modes are favored because of simplicity

$$R \equiv \frac{\mathcal{B}(B \to D_2^* \ell \bar{\nu})}{\mathcal{B}(B \to D_1 \ell \bar{\nu})}$$ = 0.4-0.7 predicted by HQET

  - world average 0.4 +/- 0.15
- We can measure
  - R from
    - $N(D^*_2) / N(D_1)$
  - Br (B -> μ D_1X)
  - Br (B -> μ D^*_2X)
- Signal has good purity – can study
  - Interference effects
  - Helicity

Conclusions

- Observed B → μ ν D** decays
- Measured Br (B → μ ν narrow D** X)

$$Br(B \to \{D_1^0, D_2^{*0}\}\ \mu\ \nu\ X) \cdot Br(\{D_1^0, D_2^{*0}\} \to D^{*+}\ \pi^-) =$$

$$0.280 \pm 0.021\ (stat) \pm 0.088\ (syst)\ \%$$

- Signal purity and statistics is good
  - Can do competitive measurements of Br and ratio of Br for two narrow D** states
- Plans : increase statistics
  - Looser selections for D^0
  - Add more decay modes for D^0
  - More luminosity